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Two New Genera and Species of Cottoid Fishes from Japan[1]

Kiyomatsu SAKAMOTO.

(Received February Ist, 1932)

Among a collection of cottoid fishes which came under my examination, two specimens were found to represent each a new genus and species. One of the two was obtained several years ago by the staff of the Iwate Fisheries Experimental Station at a great depth off the Iwate Prefecture and was put at my disposal through the courtesy of Ass. Professor K. Ebina, to whom I wish to dedicate the form with the name, *Ebinania vermiculata*, n. g. n. sp. Another one, *Neohemilepidotus japonicus*, n. g. n. sp., is based on a specimen from an unknown locality.

It is my pleasant duty to return herewith my hearty thanks to Professor A. Terao for his kind supervision during the course of my study. I am also greatly indebted to Ass. Professor K. Ebina and the staff of the Iwate Fisheries Experimental Station for many acts of kindness given me in various ways.

Ebinania, n. g.

Body tadpole-shaped, tapering from the head to the very slender tail, covered with very loose, naked, movable skin. Head extremely large, somewhat roundish above; snout obtuse, short and rounded; mandible short, its form crescentic, its arch not narrowed behind; lower jaw little shorter than the upper; jaws with very broad bands of villiform teeth, a double patches of teeth on vomer, none on palatines; no spines on head; many small dermal tentacles or cirri on under-surface of head, angle of mouth, snout, above eye, angles of opercle, and on opercle. Interorbital space very wide; eye very small. Gill membranes broadly united, jointed to the isthmus without fold across the isthmus; gills $3\frac{1}{2}$,

(1) Contribution from the Zoological Laboratory, Imperial Fisheries Institute, No. 22

no slit behind the last gill arch; gill rakers very few, short, and robust like the tubercles. Branchiostegales 5. Dorsal fins connected, very slightly notched; spinous dorsal and anterior part of soft dorsal are short, slender, flexible and entirely hidden in the skin and not vissible without dissection, as the spines and anterior rays do not rise above level of muscles; soft dorsal short and not so high, the total number about 16; anal low, of about 12 rays; pectorals long, with a broad procurrent base; ventrals I, 3, separated widely with each other, its spines extremely short and feeble, entirely hidden in the skin. Lateral line entirely obsolete.

The genus is closely related to *Psychrolutes*, but differs from it in having the vomerine teeth, cirri on head, small number of anal rays, and widely separated ventral fins.

From *Gilbertina* Jordan & Thompson (=*Gilbertidia* Gilbert & Thompson) it differs in having the vomerine teeth and bound down dorsal spines.

From *Eurymen* it differs in having vomerine teeth and no free tips at the dorsal spines.

The genus is also related to *Cottunculus* and *Cottunculoides*, but differing from the first in having no concealed preopercular spines, and from the second in having many cirri on head and bound down dorsal spines.

Ebinania vermiculata, n. sp.

(New Japanese name: Ebina-kazika.)

Head as measured from tip of snout to the end of opercular flap $2\frac{2}{5}$ in total length without caudal; greatest width of head $2\frac{3}{10}$; depth

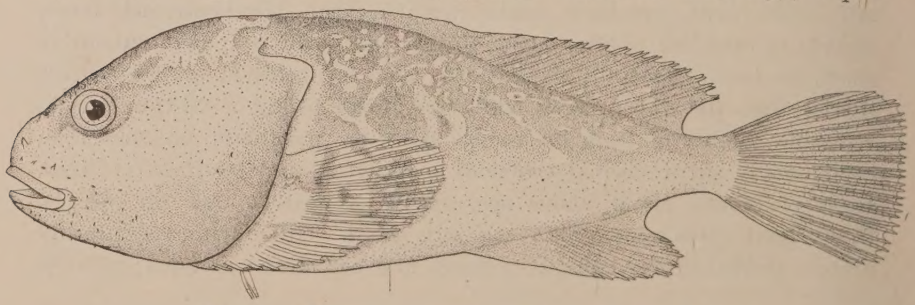

Fig. 1. *Ebinania vermiculata*, n. g. n. sp. ×ca. $\frac{1}{5}$.

of body $2\frac{4}{5}$; length of base of dorsal fin 2; base of anal fin $4\frac{1}{5}$; from snout to origin of first dorsal spine $2\frac{3}{5}$; from snout to origin of anal fin $1\frac{1}{2}$; D. VIII, 16; A. 13; V. I, 3; P. 22; C. 16; branchiostegales 5; gill rakers on first arch 0+9; eye $8\frac{1}{2}$ in head; interorbital space $2\frac{1}{5}$; snout $4\frac{7}{10}$; maxillary 3; ventrals $5\frac{1}{5}$; caudal $1\frac{7}{10}$; longest dorsal ray $2\frac{7}{10}$; longest anal ray $2\frac{9}{10}$; depth of coudal 5.

Body very robust, tadpole-shaped, rapidly tapering from the very large head to the small and compressed caudal peduncle, the greatest breadth and depth at angles of opercle. Head very broad, its breadth is equal to the length of head including the opercular flap; snout broad, obtuse and short. Gill-membranes broadly united to the isthmus, without fold across the isthmus. Mouth rather large and broadly rounded; the jaws about equal, the upper jaw slightly longer; maxillary scarcely reaching to anterior margin of orbit; the lower jaw crescent-shaped, its arch not narrowed behind. Teeth very small, villiform in many rows on the jaws, a double large patches on vomer, none on palatines. Eyes placed high, very small, its long diameter $3\frac{4}{5}$ in interorbital space. Interorbital space extremely wide, rather rounded. Two pairs of nasal pores widely separated with each other, the anterior ones at tips of long tubes. Nasal, preorbital and preopercular spines entirely absent. Bones of head cavernous. Head with rather large mucous pores; a row of 10 pores along near the anterior margin of snout; 6 pores on under side of head near the mandible, of which 4 ones in one row along near the mandible. Small barbels on the lower side of head, terminal portion of snout, above the eyes, angles of opercle and few ones on opercle, but very abundant on underside of head; angles of mouth with two rather large tentacles and few small ones.

Head and body covered with a very loose, naked, mucous and movable skin. Dorsal fins continuous, begining over the opercular angles, very slightly concave between spines and rays; spinous dorsal and rays all slender and flexible, and except the last ten rays bound down in the lax integment; the last dorsal ray not reaching to the caudal fin. Anal fin lower than dorsal, inserted somewhat posterior portion of middle of total length. The pectorals rather large, $3\frac{1}{2}$ in total length without caudal, but not reaching to the origin of the anal, its 6th–7th are the longest. Ventral spine entirely hidden in the lax skin, can not be seen without dissection as in dorsal. Caudal fin rounded with free tips of rays. Anal papilla very small. Lateral line entirely obsolete.

Color in formalin gray, paler below, back and sides clouded with whitish, head vermiculated with same color. Dorsal fin gray, with several small, irregular white marks; pectorals light gray without definite marks; ventrals white; caudal gray.

Type is a single female specimen 380 mm. long, preserved in the Zoological Laboratory, Imperial Fisheries Institute, Tokyo.

Note.—Dr. Shigeho Tanaka[1] referred a specimen from Misaki to *Cottunculus brephocephalus* Jordan & Starks,[2] but it decidedly differs from the original description and may probably be another species of *Ebinania*.

Neohemilepidotus, n. g.

The shape of the body rather robust. Head rather large and depressed. Villiform teeth on jaws, vomer, and palatines; preopercle with four spines, all simple. A small rather round slit behind the last gill; gill membranes broadly connected, free from the isthmus. Body with three bands of scales on each side, the first band of scales on back, meeting in front of dorsal; the second band along the lateral line; the third band ranging from under portion of lateral line to the belly, consists of five regular rows of pine-like, feeble and sparsely arranged scales; skin otherwise naked; the dorsals connected, the spinous dorsal not emarginate, the second spine very short, the third spine the longest, much longer than the second. Ventrals, I 4, the inner surface of the rays not armed with setae.

This genus differs from *Hemilepidotus* in the shape of the first dorsal fin (not emarginate), and in having the third band consists of five rows of pin-like scales ranging from under lateral line to the belly.

From *Melletes* it is distinguished in having three bands of scales, of which the third band of scales under the laleral line consists of five regular rows of pin-like scales, no setae on the inner surface of the ventrals, no dermal flap on head and very short second dorsal spine.

Neohemilepidotus japonicus, n. sp.

Head $2\frac{9}{10}$ in length without caudal; depth 4. Dorsal XII—20; anal 17; pectoral 17. Eye $4\frac{2}{5}$ in head; maxillary $2\frac{1}{10}$; snout $4\frac{3}{5}$; interorbital space $5\frac{1}{5}$; least depth of caudal peduncle $5\frac{4}{5}$.

Body, rather robust anteriorly, tapering into a slender and compressed

(1) Tanaka, S., Figs. Desc. Fishes of Japan, XI, p. 187, pl. 51, figs 195 and 196, 1913.
(2) Jordan, D. S. and Starks, E. C. Proc. U. S. Nat. Mus., XXVI, p. 689, 1903.

caudal peduncle. Head very large and depressed; supraorbital rim much produced with rather large and blunt tubercle-like spine in its posterior portion; interorbital space broad, little less than diameter of eye, slghtly concave, with an inconspicuous pair of longitudinal ridges; occiput

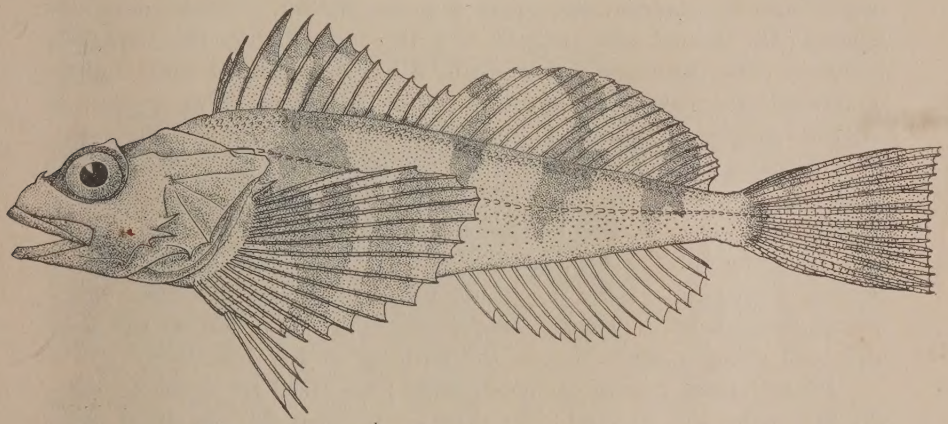

Fig. 2. *Neohemilepidotus japonicus* n. g. n. sp. ×ca. $\frac{1}{3}$

a little concave, from its both sides running a rather inconspicuous ridge obliquely backward. Mouth rather large, the maxillary reaching to little passed the middle of eye; lower jaw included. Teeth in very wide bands on jaws, vomer and palatines, wider in front of jaws than at sides. There are three bands of scales: the first band of scales on back in 3 transverse rows anteriorly diminished to 2 rows posteriorly on each side of body under the last eight soft dorsal rays; the third row of this band small and sparsely arranged; in 65 longitudinal series on the first row. The second band of scales along the lateral line small, sparsely arranged, inserted below last dorsal pine, disappearing below the last seventh dorsal ray, in 19 longitudinal series. The third band of scales anteriorly with five rows, posteriorly with four; these rows ranging from under portion of lateral line to the belly; the scales very small, pin-like, feeble and sparsely arranged; in 30 longitudinal series on the first row, inserted under the eighth dorsal spine, disappearing below the last third dorsal ray; the second row inserted under third dorsal ray, disappearing below last seventh dorsal ray; the third row from under fourth dorsal spine to the end of last dorsal ray; the fourth one from third dorsal ray to the end of caudal peduncle; the

lowest one from under last dorsal spine to the last second anal ray, which is very small, feeble and like the dermal cirri. Nasal spines rather long and sharp. Edges of the preorbital without spines. Opercle with a flat spine at the end of a ridge. Preopercle with four spines; the two upper ones the largest, the uppermost one strong, directed obliquely upward; the second one straight and the longest, directed straightly backward; the third one rather small, directed backward and slightly downward; the lowest one small, directed downward. Two spines on edge of subopercle, the upper one directed backward and slightly downward, situated behind and just above the next to the tip of preopercular spine; the lowest one at union of subopercle with interopercle, the spine directed backward. A long and feeble spine immediately above the upper margin of the operclar flap, parallel with it; below and slightly anterior portion of this spine there is a blunt tubercular spine. Humeral spine strong, longer than the longest preopercular spine. No flap on the body and head except a short flap at the posterior end of maxillary.

Dorsal spines graduated, not notched; the third spine the longest; the first spine, $3\frac{9}{10}$ in head; the second very short $3\frac{1}{5}$; the third, $2\frac{3}{10}$; the fourth, $2\frac{1}{5}$; the next to the last shortest, $4\frac{9}{10}$. The soft dorsal higher than the spinous; the seventh the longest, $2\frac{1}{10}$ in head. Pectoral fins reaching to opposite base of first or sacond anal ray, the fourth from the top the longest, $1\frac{1}{10}$ in head. Ventrals not reaching to vent; $1\frac{1}{2}$ in head; the rays I, 4. Anal rays slender, the membrane rather deeply incised, the fifth ray the longest, $2\frac{9}{10}$ in head. Caudal slightly emarginated, or truncated, its length $1\frac{1}{2}$ in head.

Color in formalin gray above, paler below, crossed by four dark bars, whicn are usually much narrower than the interspaces, and are continued upward on the dorsal fin; the first one under fifth to eighth dorsal spine; the second under third to fifth soft dorsal; the third under ninth to thirteenth soft dorsal; the fourth under last five dorsal says; head dark gray, without definite marks. Pectorals light gray, crossed with three dusky bands, which are much wider than the interspaces. Ventrals and anal white. Caudal gray, crossed with broad dark bars in its middle portion.

Described from a female specimen 270 mm. long. Type in the Zoological Laboratory, Imperial Fisheries Institute, Tokyo.

The cotype is a male, 254 mm in total length; the ventral fin very long, slightly longer than the head.

On a Collection of Tide-Pool Fishes from Prov. Bôsyû, with a Description of One New Species[1]

Kiyomatsu Sakamoto.

(Received February Ist, 1932)

From August 29 to September 1, 1931, I had opportunity to collect the tide-pool fishes from three localities on the south-eastern coast of Prov. Bôsyû, viz., Sirahama, Hutomi, and Kominato. They are referable to 34 species which are listed in the present paper. Of the above number of species, one seems to me to be new to science and is described here for the first time, namely, *Clariger sirahamaensis*. The inclusion of this species under the genus *Clariger*, however, has necessitated to change the definition of the generic characters, as will be given later on.

It may be mentioned that Tanaka[2] studied 26 species of tide-pool fishes from Misaki, a locality not far from Prov. Bôsyû. Many of them are also represented in my collection and the asteriks mark those which were obtained by the above-mentioned ichthyologist. Remarkably enough, a rather high per cent of tropical fishes, marked with crosses, is found in the tide-pool collection of Prov. Bôsyû, apparently due to high temperature prevailing there.

I wish return herewith my hearty thanks to Professor A. Terao for his kind supervision during the course of my study.

Family Mugilidae

1. *Mugil cephalus* Linné.

Hutomi. Numerous specimens 10 cm long from large sandy pools.

Family Kuhliidae.

2. *Safole taeniura* (Cuvier & Valenciennes)

Hutomi; Kominato. Many specimens 3–5 cm long from rather deep rocky pools.

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(1) Contributions from the Zoological Laboratory, Imperial Fisheries Institute, No. 23

(2) Tanaka, S. On a Small Collection of Tide-Pool Fishes from Misaki, with Descriptions of Two New Species. Annotationes Zoologicae Japonenses. vol. VII. Part 1. 1908.

Family Epinephelidae.

3. *Epinephelus moara* (Temminck & Schlegel)
Sirahama. Two specimens 20 cm long, from a deep pool.

Family Girellidae.

* 4. *Girella punctata* Gray.
Sirahama; Hutomi; Kominato. Many young specimens, the largest 5 cm.

Family Pomacentridae.

† 5. *Abudefduf saxatilis* (Linné)
Hutomi. Two immature specimens 5 cm. long.
† 5. *Abudefduf sordidus* (Forskal)
Hutomi; Kominato. Immature, 5 cm. long; rather common.

Family Coridae.

† 7. *Stethojulis terina* Jordan & Snyder.
Sirahama; Hutomi; Kominato. Many young and adult specimens.
* *Thallasoma cupido* (Temminck & Schlegel)
Sirahama; Hutomi; Kominato. Numerous; immature.

Family Scaridae.

9. *Calliodon ovifrons* (Temminck & Schlegel)
Hutomi. One immature specimen, 4 cm long; rare.

Family Chaetodontidae.

10. *Coradion modestum* (Temminck & Schlegel)
Sirahama; Hutomi; Kominato. Rather common in deep rocky pools, but all immature, 3 cm. long.
11. *Microcanthus strigatus* (Cuvier & Valenciennes)
Hutomi. Ten specimens, all immature, the largest being 5 cm. in length.

Family Acanthuridae.

11. *Xesurus scalprum* (Cuvier & Valenciennes)

Hutomi. A small specimen, 3 cm. long.

Family Scorpaenidae.

* 13. *Hypodytes rubripinnis* (Temminck & Schlegel)
Sirahama; Hutomi; Kominato. Numerous specimens, including young, immature, and adult.

Family Cottidae.

14. *Ocynectes maschalis* (Jordan & Starks.)
Hutomi. One adult specimen from a rocky pool.

Family Eleotridae.

* 15. *Eviota abax* (Jordan & Snyder)
Kominato; Hutomi; Sirahama. Many specimens.

Family Gobiidae.

16. *Rhinogobius giurnus* (Rutter)
Hutomi. Common.

17. *Rhinogobius campbelli* (Jordan & Snyder)
Sirahama; Hutomi. Common.

18. *Mapo poecilichthys* (Jordan & Snyder)
Sirahama; Hutomi; Kominato. Common in shallow pools.

19. *Zonogobius boreus* Snyder.
Sirahama; Kominato. Rather common.

* 20. *Chasmichthys dolichognathus* (Hilgendorf)
Sirahama; Hutomi; Kominato. Most numerous among all the tide-pool fishes.

* 21. *Chasmichthys gulosus* (Guichenot)
Sirahama; Hutomi; Kominato. Numerous.

* 22. *Clariger cosmurus* Jordan & Snyder.
Sirahama; Kominato. Rare.

23. *Clariger sirahamaensis*, n. sp.
(New Japanese name: Seguro-haze)

Head, as measured to end of opercular flap, $3\frac{3}{5}$ in length without caudal; depth $6\frac{7}{10}$; depth of caudal peduncle $6\frac{4}{5}$; eye $6\frac{2}{5}$ in head; snout $4\frac{1}{5}$; interorbital space $3\frac{1}{10}$; dorsal III, 9; anal 9; pectoral 19.

Dorsal and ventral contours of body not elevated, almost of the same depth throughout; cylindrical anteriorly, much compressed behind. Back between dorsals rather sharply ridged by the skin. Head broad,

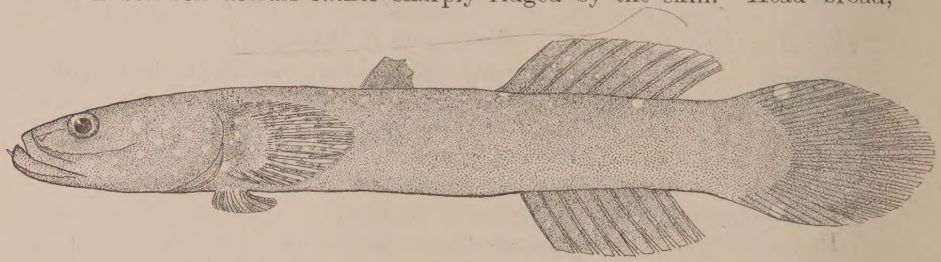


Fig. 1. *Clariger sirahamaensis*, n. sp. ×5½.

much wider than the body, and considerably depressed, its top flattened and not concave; snout broad, rather short and blunt; lower jaw projecting. Maxillary extending backward to a point beneath middle of eye. Mouth cleft almost vertically directed anteriorly, but horizontally running posteriorly. Tongue broad, deeply notched anteriorly. Teeth very small, arranged in narrow bands on both jaws; vomer and palatines toothless. The eyes directed obliquely upward; interorbital space flat and very broad, more than twice as long as the diameter of eye. Gill clefts restricted to the sides, broader than the base of pectorals. The skin of the snout and chins wrinkled, a ridge of the skin somewhat under the eye. A pair of short, flattened barbels in front of eye, which by far nearer to tip of snout than eye; a pair of the same at the symphysis.

Head and body entirely naked. Dorsals separated, the first dorsal spine inserted about midway between snout and origin of the caudal fin; soft dorsal and anal with fleshy membranes; the base of the second doreal slightly longer than that of anal; no membrane posteior to the soft ray. Anal inserted below between second and third soft dorsal rays. Caudal rather pointed at the tip. Pectorals somewhat acutely rounded. Ventral united, free posteriorly.

Body and fins except the pectoral fins dark gray; pectorals white, except its base, mottled with irregular shape of small black spots; edges of second dorsal, anal and caudal white; at the upper and lower edges of caudal near its base with a small round white spots, and the same few ones on body; occiput with a pair of small white spots, which separated widely with each other.

This species is known from a single female specimen, 33 millimaters long, obtained by poisoning with bleeching powder in a gravelly tide-pool of Sirahama, Prov. Bôsyû. Type in the Zoological Loboratory, Imperial Fisheries Institute, Tokyo.

This species may be principally distinguished from the hitherto known two species of this genus by the following characters.

	C. cosmurus	*C. exilis*	*C. sirahamaensis*
Scales.	A row of rather large, round, cycloid scales in median part of caudal peduncle.	The scales extending forward over the angular region to or beyond the base of the spinous dorsal.	Entirely wanting.
Shape of body.	Slender, its depth $7\frac{3}{4}$ in length of body.	Very sleneer, its depth 8 in length of body.	Rather robust, its depth $6\frac{7}{10}$ in length.
Width of inter-orbital space.	Very narrow, about equal to the diameter of eye.	Moderate, little longer than eye.	Very wide, more than twice as long as eye.
Berbels in sub-orbital area.	Present	Present	Absent
Berbels at the symphysis.	Absent.	Present.	Present.
Colouration	White (pinkish).	White (pinkish).	Dark gray.
Dorsal fin.	III-12.	III-11.	III-9.
Anal fin.	12.	11.	9.

It is clear from the above list that the new species differs so much from the other two in some important characters that the genus *Clariger* should be emended as follows :—

Clariger Jordan & Snyder, emend.

This genus has the form and appearance of *Luciogobius*, differing in the presence of a short spinous dorsal of three slender spines. The body is elongate, the head broad and flattened, and the skin with or without cycloid scales on the tail. Below the eye there are generally a few short filaments or barbels, but sometimes entirely wanting.

* 24. *Luciogobius guttatus* Gill.
Kominato. One small specimen.

25. *Inu ama* Snyder.
Sirahama. One adult specimen.

26. *Expedio parvulus* Snyder.
Sirahama. Twelve adult specimens.

Family Gobiesocidae.

* 27. *Aspasma minima* (Döderlein)
Hutomi; Kominato. Two small specimens.

Family Clinidae.

* 28. *Enneapterygius etheostoma* (Jordan & Snyder)
Hutomi; Kominato. Common.
* 29. *Zacalles bryope* Jordan & Snyder.
Sirahama. One small specimen.

Family Blennidae.

30. *Blennius yatabei* Jordan & Snyder.
Hutomi. One small specimen.
* 31. *Petroscirtes elegans* (Steindachner)
Sirahama; Hutomi. Common.
* 32. *Salarias enoshimae* (Jordan & Snyder)
Sirahama; Kominato. Common.

Family Pholidae.

* 33. *Dictyosoma burgeri* Van der Hoeven.
Sirahama. Two specimens, found under large rocks; rare.

Family Antenariidae.

34. *Antennarius sanguifluus* Jordan.
Kominato. One immature specimen, 2.5 cm. in length.

Note.

It is worth mentioning that Tanaka (*op. cit.*) obtained the following 12 species in the tide-pools of Misaki besides the fourteen which are marked with the asterisks in the above list:—

Hippocampus japonicus Kaup, *Epinephelus diacanthus* (Cuvier & Valenciennes), *Gonistius zonatus* (Cuvier & Valenciennes), *Halichoeres tremebundus* Jordan & Snyder, *Sebastichthys elegans* (Steindachner & Döderlein), *Sebastichthys mitsukurii* (Cramer), *Hexagrammos otakii*

Jordan & Starks, *Pseudoblennius cottoides* (Richardson), *Pterogobius daimio* Jordan & Snyder, *Aspasma misakia* Tanaka, *Zoarchias veneficus* Jordan & Snyder, and *Zoarchias neglectus* Tanaka.

Perhaps these may be found also in Prov. Bôsyû, and the twenty species of Bôsyû including the new one which are not found in Tanaka's collection may also occur in Misaki, since the two localities are closely situated and under the influence of the same warm current, "Kuro-Siwo" (Black current). Of 46 species which seem to me to be common to the tide-pools of Misaki and Bôsyû, one is subarctic, namely *Zoarchias veneficus* Jordan & Snyder, but all the others are either temperate or tropical. In the fishes which pass young or immature stage in the tide pools in the above-mentioned localities but quit there where they are adult, the percentages of temperate and tropical species are nearly the same. Those fishes which inhabit the tide-pools throughout the whole life are, however, exclusively temperate, and form a greater part of the inhabitants there. These belong to the families, *Cottidae, Eleotridae, Gobiidae, Gobiesocidae, Clinidae, Blennidae, and Pholidae.*

Sexual Dimorphism in a File-fish, *Cantherinus modestus* (Günther)[1]

Ken-ich Ebina

(Recieved February 1st, 1932.)

During my investigation of the scales of file-fishes (Monacanthidae), I have noticed some significant differences in the external characters of the two sexes of one of them, *Cantherinus modestus* (Günther). The author wishes to express herewith his indebtedness to Professor A. Terao for his kind supervision during the course of his study on this fish.

The material on which the present paper is based was mostly obtained from the Tokyo fish market, and examined in a fresh condition; no formalin specimen was used.

The two sexes are, first of all, easily distinguished by the dorsal profile of the head; it is very convex in the male whereas it is almost completely straight in the female. On disection it is found that this difference corresponds to that of the shape of the frontal and supraoccipital bones. Perpendicular distance of the farthest frontal point from the straight line passing through the tip of snout and base of dorsal spine amounts to 8–10 hundredth the latter in the male specimens ranging from 225 to 316 mm. in length. Secondly, the ratio of the body depth to the body length is markedly different in the two sexes when the speciemens are mature, i. e. usually 2.4–2.7 at most 2.89, for the male but 2.1–2.2 for the female. But since I have observed that one adult male has smaller ratio, 2.00, and one immature female has a rather large ratio, 2.68, acriterion which can not be taken as valid for distinguishing the sexes, if used by itself.

No.	male			No.	male		
	length	height	length:height		length	height	length:height
1	316 mm	115 mm	2.74%	4	300 mm	125 mm	2.40%
2	312	116	2.68〃	5	300	125	2.40〃
3	308	130	2.37〃	6	300	120	2.50〃

(1) Contributions from the Zoological Laboratory, Imperial Fisheries Institute, No 25

No.	male			No.	male		
	length	height	length:height		length	height	length:height
7	295 mm	103 mm	2.85%	12	265 mm	100 mm	2.65%
8	290	115	2.52〃	13	263	91	2.89〃
9	285	115	2.47〃	14	240	105	2.28〃
10	281	110	2.55〃	15	225	100	2.25〃
11	280	140	2.00〃				

No.	female			No.	female		
	length	height	length:height		length	height	length:height
1	305 mm	140 mm	2.14%	6	270 mm	122 mm	2.21%
2	297	133	2.23〃	7	263	125	2.05〃
3	280	130	2.15〃	8	240	110	2.18〃
4	275	131	2.10〃	9	224	85	2.63〃
5	275	130	2.10〃				

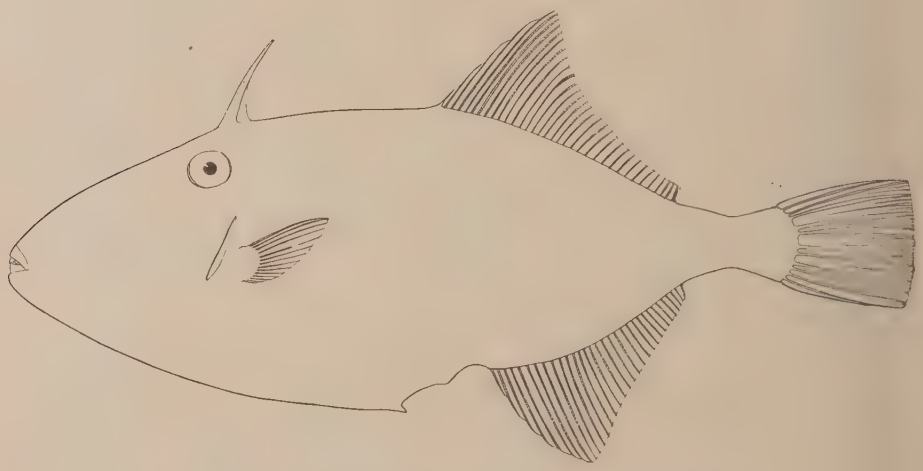


Fig. 1. Male of *Cantherinus modestus* (Günther) ca. × $\frac{1}{3}$

Fig. 2. Female of *Cantherinus modestus* (Günther) ca. × $\frac{1}{3}$

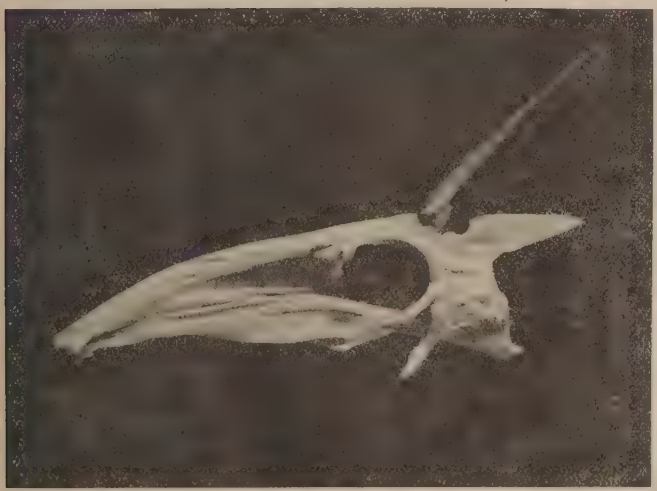


Fig. 3. Skull of male × $\frac{1}{2}$

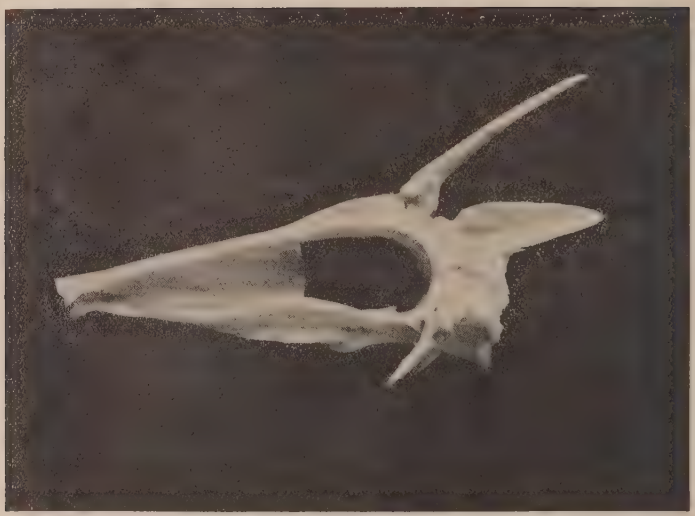


Fig. 4. Skull of female ×½

Buccal Incubation in the Two Sexes of a Percoid Fish, *Apogon semilineatus* T. & S.

Ken-ichi Ebina

(Received February 1st, 1932.)

The incubation of the ova in the buccal cavity has been observed in the male of some fishes belonging to the family of Apogonidae (= Amiidae). Among the Japanese species of this family three have been recorded in this respect, viz., *Apogon lineatus* Temminck & Schlegel, *Apogon notatus* (Hottuyn), and *Chelidodipterus quinquelineatus* Cuvier & Schlegel. However, Mr. Kiyomatsu Sakamoto informs me that Professor I. Amemiya, of the Faculty of Agriculture, of the Tokyo Imperial University, has of late obtained a female speciemen of *Apogon lineatus* with a dense mass of the ova in the buccal cavity. While at Tateyama, Prov. Bôsyû, in summer of 1931, my attention was called to the fact that both the male and female speciemens of *Apogon semilineatus* T. & S. have the habit of the buccal gestation. The present paper embodies my field and laboratory observations on this fish.

It is my pleasant duty to return herewith my hearty thanks to Professor A. Terao for this kind supervision during the progress of my study.

The species in question is widely distributed along the Pacific coasts of middle to southern Japan. The members of this form are found in Tateyama Bay swarming on rocky bottom and on *Zostera* bed, which are 3–30 meters deep, and spawning from July to September. A haul of a fishing net in their habitat resulted on July 25 in an almost ex-

(1) Contributions from the Zoological Laboratory, Imperial Fisheries Institute, No. 24.

(2) Tanaka, S. Buccal incubation in *Amia lineata*. Zool. Mag. (Dobutsu. Zass.) Vol. 27, 501–502, 1915 (in Japanese).

(3) Utida, K. Fishes, Cyclostomata, and Cephalocordata. Iwanami Series of Biology, Vol. p. 75 (in Japanese).

(4) Sakamoto, K. Buccal incubation in the percoid fish, *Apogon lineatus* T. & S. This Journal, Vol. 26, No. 1. 1930.

(5) Forler, H. W. & B. A. Been. The fishes of the families *Amiidae*, *Chandidae*, *Dulcidae* and *Serranidae* obtained by the U. S. Bureau of Fisheries steamer "Albatross" in 1907 to 1910. U. S. Nat. Mus. Bull., No. 100, Vol. 10, 1930.

(6) personal information.

clusive gathering of adult speciemens, consisting of 232 males and 291 females, of this fish which are 70–100 mm., mostly about 80 mm., long. The collection included 17 male and 24 female gestating speciemens besides 20 egg-masses which had been undoutedly being incubated in

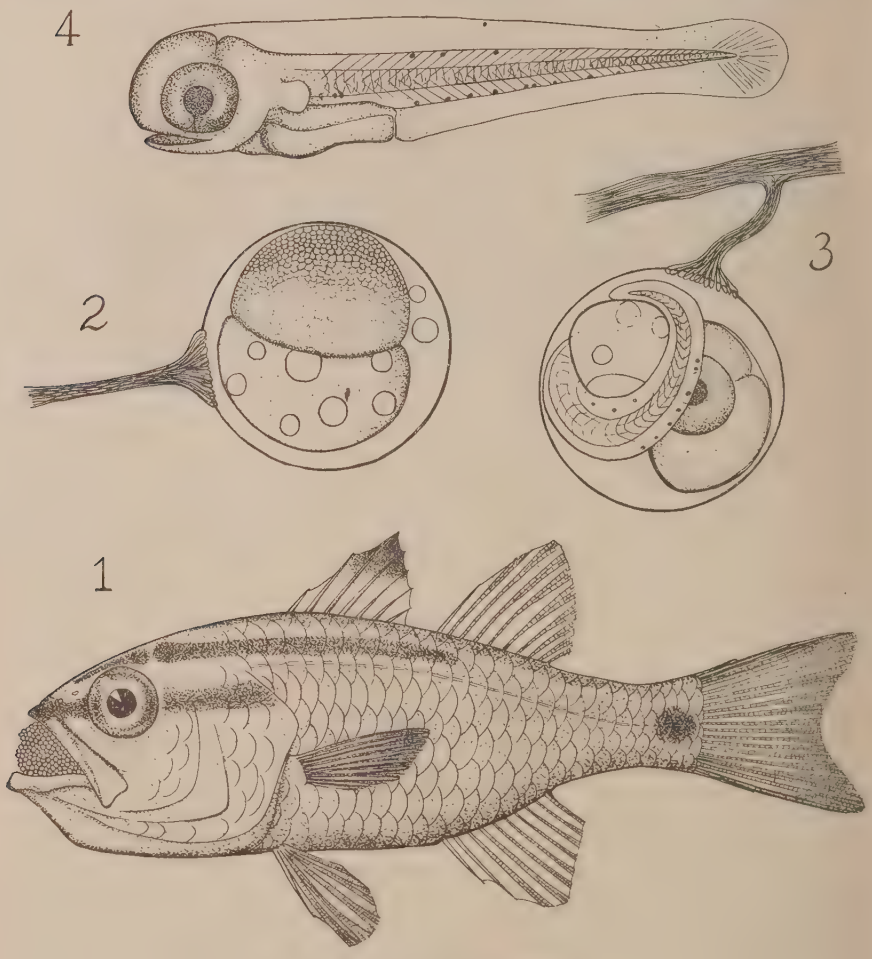


Fig. 1. *Apogon semilineatus*

1. Male ×1.
2–3. Eggs ×60.
4. Just hatched fry ×39.

the mouth of the corresponding number of individuals in the catch but were disgorged by them when fished.

The mass of eggs with which the mouth is crammed to its fullest capacity is almost ellipsoidal in shape, and measures, on the average, 30 mm. in length, 25 mm. in width, and 15 mm. in height. All the eggs are united with each other by thread-like substance and are found when examind under the microscope in the same stage of development. It may be mentiond, however, that, I have observed rarely two or three egg-masses, each showing a different stage of development from the other, contained in the mouth of one speciemen.

The ovum is nearly spherical, with the diameter 58–60 μ long, translucent and orange in colour when it is in an early stage of development. The fry measure 2.3 mm. long, when they have just hatched, and are still found in the mouth of adult for some time after the hatching.

New Freshwater Species of Chaetomorpha.

(with Plate I.)

By S. Ueda

Chaetomorpha Okamurai sp. nov.

Filaments caespitose, gregarious, prostrate, attached by branched fibrous roots, somewhat flaccid, almost cylindrical except lower segments, 10–15 cm. long, deep green; segments mostly 70 μ in diam., shoster segments 80–100 μ in length, longer ones 400–500 μ; walls usually 2.5–3 μ thick and thickened up to 7 μ at joints, striated longitudinally; the lowest segment usually much elongated, about 1.5–3.2 mm in length, emitting long, slender, coralloid branches from the base. Multiplication, by fragmentation and new shoot arising from stolon; asexual reproduction, by 4-ciliated zoospores.

Hab.: on stones, and on the side of well or in gutter. Tokyo. Shirahama (Bôshyû), Goi (Bôshyû) and Kamisuwa (Nagano-Ken).

The young fronds are pale green and have somewhat long cylindrical segments being usually 8–10 times long as diameters, 50–60 μ thick and 400–500 μ long. As the plant becomes fertile or nearly fertile, the segments swell slightly into a short barrel-shape; and the colour changes to deep green. Cell contains many nuclei. The walls of the segments are mostly 2.5–3 μ thick, rarely 4.5 μ, much more thickened at joint as far as 7 μ. The walls of older segments present longitudinal striations. In the lower portion of frond, segments elongate and become narrower, the basal one especially elongating with very thick wall. The basal segment emits from its base a few long branched fibrous roots, from which new fronds arise as in *Ch. Media* and some of Cladophora.

Zoospores are formed in almost all cells simultaneously in the some frond except a few lower segments. They escape through an opening (rarely two) which is formed nearly in the middle of the fertile cells; they germinate after a short resting period and grow up into new plants.

(1) F. S. Collins:—Some New Green Algae. Rhodora (Journal of the new England) vol. 9. no. 106. 1907. Botanical club.

(2) K. Yendo:—Novae Algae japonicæ, Decas I-III. The Botanical Magazine vol. XXXIV. No. 397. 1920.

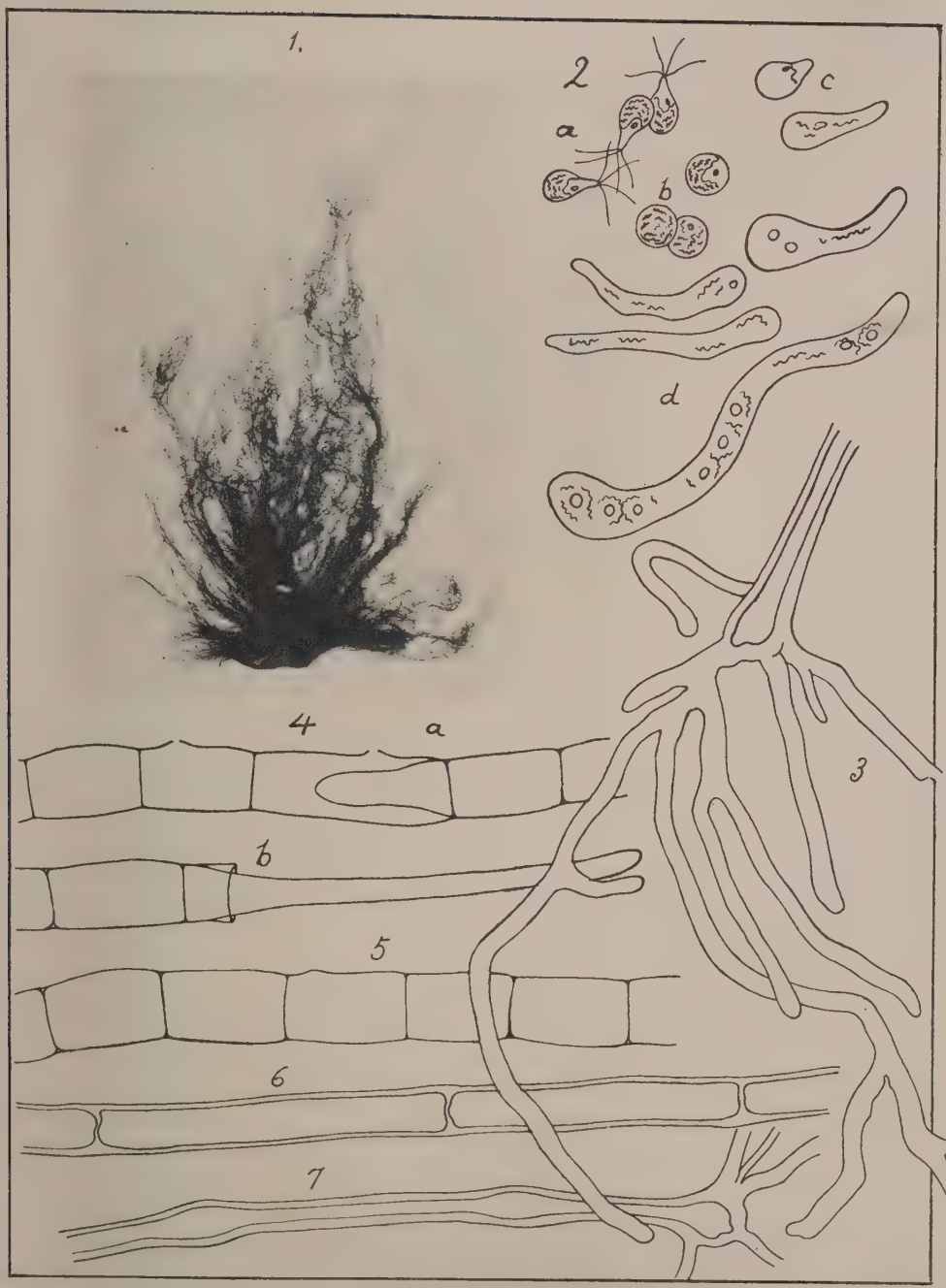
Zoospore is pear-shaped, $20 \times 12\,\mu$; it possesses one nucleus, one stigma and 4 cilia of equal length and pale green, parietal, chloroplasts. The fronds often become fragmented on the death of the emptied cells; the remaining portions above and below the emptied cells are able to grow as a new frond.

That the plant in question is a new species of Chaetomorpha is beyond any doubt. It differs from other known freshwater species by having stoloniferous branching roots in these thickness of segments, and in the propotion of their length and width. The attachment of the known freshwater species is mostly disc-shaped while in the present it is branched and fibrous. In the habit of the attachment the present species is closely related to both *Ch. Chelonum* Collins[1] and *var japonica* Yendo[2], but they differ particulally in the thickness of the segment and in the propotion of size; moreover, their attachment is said to be "pluricellular", while that of the present species shows very rarely one (or perhaps more) partition in some branch of root.

We find the present plant growing through the whole year in Tokyo, and in spring and autumn it is very much flourished. Dr. Okamura had early discovered the plant in a well at Shirahama (Boshyu) and Prof. Higashi collected them from Kamisuwa, Goi, Mikawashima, etc.

Explanation of Plate.

Fig. 1. Fronds of *Chaetom rpha Okamnrai* Ueda (ca. $\frac{1}{3}\times$)
2. Zoospores and their germinations. (ca. 500×)
   a. 4-ciliated zoospore with one stigma.
   b. resting state.
   c, d. Spores in the development.
3. Holdfast of the frond. (ca. 240×)
4. a, b. Portion of fully grown segments, showing the emptied cell and a new segment arising from the remaining portion beneath the emptied cell. (ca. 100×)
5. Middle portion of fully grown frond. (ca. 100×)
6. Lower portion of frond. (ca. 100×)
7. Basal portion of the lowerest segment. (ca. 100×)



Chaetomorpha Okamurai sp. nov.

Relation between the Growth of Bacteria and the Change of Quality of Scomber Flesh at Low Temperatures.

Kuman Saruya

(Received February 1st, 1932.)

In low-temperature industry, two grades of low temperatures are generally applied to objects according to different purposes. The one in near 0°C and used for the transportation of raw-fish, and for the storing of eggs, fruits and vegetables.

The other is decidedly lower than 0°C and utilized for refrigeration and storage of foods.

The present study was undertaken to determine the relation between the growth of bacteria and the change of quality of Scomber flesh at each of the two grades of low temperatures.

Experimental.

1. Materials.

   Fresh Scomber from the sea near Tokyo.

2. Temperatures of storages.

   Temperatures of storages were 2.5°～-0.5°C and -8.0°～-9.5°C.

3. Observations of the external changes.

   Fresh Scombers were stored in the refrigerators and were examined at times as to the external changes.

4. Bacteriological observations.

   The 0.8 % physiological salt solution was added to the minced flesh taken in flask, and the bacteria were suspended in the solution. The solution was diluted suitably, and a certain volume of it was pourred into Petri's dish with agar medium, and the dish was kept in an incubator at 25°～30°C. After 48 hours, colonies appeared were counted by the naked eye, and the number of bacteria per 1 gm of flesh was thus calculated.

   On the other hand, bacteria separated from fresh and stored (at 2.5°～-0.5°C) flesh, were cultured in Petri's dish at 2.5～-0.5°C, and the development of colonies was observed.

5. Chemical experiments.

Amino nitrogen was determined by Van Slyk's method.

Amine and ammonia nitrogen was determined by the method of F. C. Weber and J. B. Wilson.[1]

Namely, potassium carbonate and potassium oxalate were added to the sample, and the amine and ammonia nitrogen produced was absorbed by $\frac{N}{10}$ H_2SO_4 solution which was titrated with $\frac{N}{10}$ NaOH solution.

Results.

1. External appearance.

Scomber flesh did not freeze for 21 days at 2.5°~-0.5°C. After 14 days its smell was putrefying, and after 21 days its putrefaction was distinctly observed.

At -8.0~-9.5°C, however, Scombers lost somewhat the luster of skin after 21 days.

2. Growth of bacteria.

As shown in Table II and Figs I & II bacteria propagated when they were cultured at 2.5°~-0.5°C.

The increase of the number of colonies obeys the formula of the population growth of organisms.

$$y=\frac{k}{1+e^{a+bx}}, \quad \text{where}$$

x: Time of culturing in days.
y: Number of colonies.
k: Maximum number of colonies.
a, b: Constants.

Table I

Number of bacteria contained in 1 gm of Scomber flesh.

Time of storing in days	Number of bacteria contained in 1 gm of Scomber flesh	
	Stored at 2.5°~-0.5°C	Stored at -8.0°~-9.5°C
Fresh	4,400	760
7	71,280	860
14	170,265,000	330
21	827,435,000	740

TABLE II

The increase of the number of the colonies of bacteria separated from the fresh and stored (at 2.5°～-0.5°C) flesh, when cultured at 2.5°～-0.5°C.

Time of storing in days	Number of colonies per 1 gm of fresh Scomber flesh	Number of colonies per 1 gm of Scomber flesh stored 7 days at 2.5°～-0.5°C	Number of colonies per 1 gm of Scomber flesh stored 14 days at 2.5°～-0.5°C
1			
2			Though colonies were found after 2 days, they were two small to be counted by the naked eye.
3			
4			
5			
6		No colonies were found until this day	
7	No colonies were found until this day	36,400	185,107,000
8	170	144,100	
9	440	219,300	
10	720	226,200	
11	990	237,100	
12	1,220	241,900	
13	—	246,800	
14	1,660	248,500	
15	2,340		
16	2,410		
17	2,430		
18	2,450		
19	2,460		
20	2,500		
21	2,520		

In the case bacteria separated from fresh Scomber flesh the following values of the constants were obtained :—

$$y = \frac{2550}{1 + e^{6.23 - 0.52x}}$$

The observed and calculated numbers of colonies are presented in the following table.

Table III

The observed and calculated numbers of colonies of the bacteria (per 1 gm of Scomber flesh) separated from fresh Scomber flesh, when cultured at 2.5°~-0.5°C.

x (Time of culturing in days)	y (Number of colonies)	
	Observed value	Calculated value
8	170	280
10	720	670
12	1,220	1,270
14	1,660	1,890
16	2,410	2,270
18	2,450	2,450
20	2,500	2,510

x: Time of culturing in days.
y: Number of colonies.

$$y=\frac{2550}{1+e^{6.23-0.52x}}$$

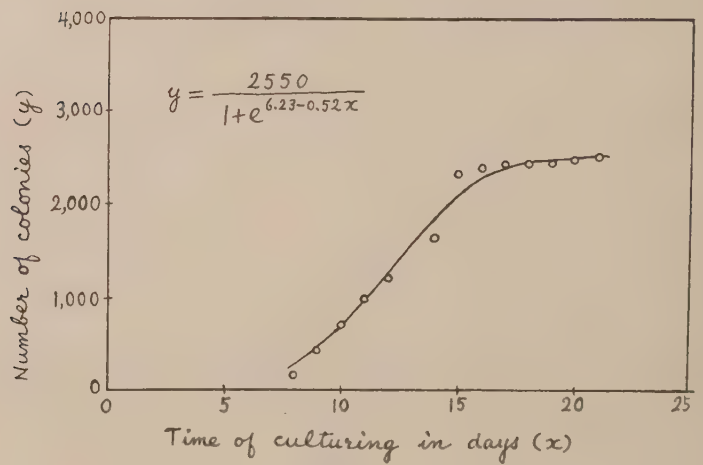


Fig. 1.

The increase of the colonies of bacteria (per 1 gm of Scomber flesh), separated from fresh Scomber flesh, when cultured at 2.5°~-0.5°C.

In the case bacteria separated from Scomber flesh which was stored

7 days at 2.5°～–0.5°C were cultured at 2.5°～–0.5°C the following equation was obtained.

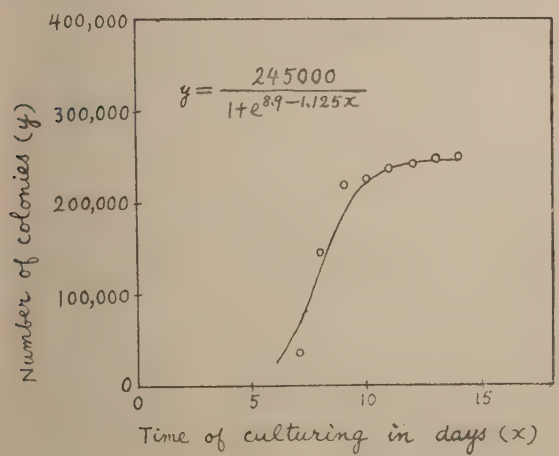
$y=\frac{245000}{1+e^{8.9-1.125x}}$, where the variables are the same as in the preceding equation.

The observed and calculated numbers of colonies are presented as follows.

TABLE IV

The observed and calculated numbers of colonies (per 1 gm of Scomber flesh) which appeared when bacteria, separated from Scomber flesh stored 7 days at 2.5°～–0.5°C, were cultured at 2.5°～–0.5°C.

x (Time of culturing in days)	y (Number of colonies)	
	Observed value	Calculated value
7	36,400	65,000
8	144,100	128,500
9	219,300	190,000
10	226,200	224,000
11	237,100	236,500
12	241,900	243,000
13	246,800	244,500
14	248,500	245,000



x: Time of culturing in days.

y: Number of colonies.

$y=\frac{245000}{1+e^{8.9-1.125x}}$

Fig. 2

The increase of number of colonies (per 1 gm of Scomber flesh) when bacteria, separated from Scomber flesh stored 7 days at 2.5°～–0.5°C, were cultured at 2.5°～–0.5°C.

3. Chemical change.

Table V

Chemical change of the quality of Scomber flesh stored at 2.5°～-0.5°C.

Time of storing in days	Amino nitrogen (%)	Amine and Ammonia nitrogen (%)
1	0.15	—
2	—	0.02
8	0.16	0.01
15	0.14	0.03
22	0.18	0.04

Table VI

Chemical change of the quality of Scomber flesh stored at -8.0°～-9.5°C.

Time of storing in days	Amino nitrogen (%)	Amine and Ammonia nitrogen (%)
Fresh	0.15	0.01
14	0.17	0.02
21	0.17	0.02

Summary and conclusions

1. To study the relation between the growth of bacteria and the change of quality of Scomber flesh, stored at 2.5°～-0.5°C (near 0°C) and -8.0～-9.5°C respectively for three weeks, a series of experiments has been made.

2. External change.

Scomber flesh did not freeze for 21 days at 2.5°～-0.5°C. After 14 days its smell was putrefying, and after 21 days its putrefaction was distinctly observed.

At -8.0°～-9.5°C, however, Scombers lost only the luster of skin somewhat after 21 days.

3. Growth of bacteria.

When Scomber flesh was stored at 2.5°～-0.5°C, bacteria propagated, remarkably between 7th day and 14th day after storing.

The increase of number of colonies, which appeared on agar medium when bacteria were separated from Scomber flesh and cultured at 2.5°～-0.5°C, conforms to the equation of population growth.

$$y = \frac{k}{1 + e^{a+bx}}, \quad \text{where}$$

x: Time of culturing in days.
y: Number of colonies.
k: Maximum number of colonies.
a,b: Constants.

When Scomber flesh was stored at -8.0°～-9.5°C, no growth of bacteria was observed.

4. Chemical change.

When Scomber flesh was stored at 2.5°～-0.5°C either the content of amino nitrogen or amine and ammonia nitrogen increased. This fact is in harmony with the previous investigation[2] concerning the relation between the putrid flesh and the content of amine and ammonia nitrogen.

When Scomber flesh, however, was stored at -8.0°～-9.5°C for 21 days, no change occurred in the content of amino nitrogen and amine and ammonia nitrogen, though a slight change occurred by the time the flesh was frozen. This fact is also in harmoy with the previous investigations[3].

The author wishes to express his sincere thanks to Prof. Kimura for his kind and continued interest during the course of this work.

His thanks also due to Profs. Miyama, Ōya, Terao, Tanchi and Gotō for their much helpful advices and valuable criticisms.

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(1) F. C. Weber & J. B. Wilson :—The Jl. of Ind. & Eng. Chem. Vol. 11, No. 2, 1919.
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A New Form of Electric Fish Screen.

Morisaburô Tauti, *Rigakuhakusi.*

(Received February 1st, 1932.)

With a view to prevent fishes from entering a ditch, Hessey[1] erected linearly a number of iron rods at equal intervals across the entrance of it and used them as electrodes to make a screening electric current in water. Burkey[2] passed, for the same purpose, a lateral electric current across a water-canal with several plank- or net-electrodes standing erectly along both sides of it and also a surface-bottom electric current in water with a set of several electrodes, some floating on the surface of water and one lying on the bottom of the canal, and he adjusted the terminal voltage in both cases in such a way that fishes may meet the current of gradually increasing intensity as they further continue their progress. Formerly, Sugii and the present author[3] studied the possibility of stopping a fish-group by supplying an alternating electric current of 50 cycles single phase with Hessey and Burkey's mode of the arrangement of electrodes. McMillan's screen[4] consisted of several vertical thick pipe electrodes set in two rows at regular intervals. Okada[5] made a statistical investigation on stopping a fish-group by using an odd number of plane grating electrodes supported vertically across a stream.

With regard to the influence of an electric current on fishes, Scheminzky[6] found that when the intensity of the current, either direct or alternating, gradually increases, four successive steps of the responses take place. McMillan[4] and Okada[7] showed that the voltage gradient

(1) M. Tamura: Fish-stopping apparatus using electric current. *Suisankai* (*Tsy.* 11).
(2) H. Sühara: Burkey's electric fish screen. *Suisankai* (*Tsy.* 11).
(3) T. Ohta: Investigations on electric current and living fish. *Suisan Kenkiushi.* XIX, 12 (1924).
(4) F. O. McMillan: Electric fish screen. Bulletin of the Bureau of Fisheries. XLIV (1928). Document No. 1042.
(5) M. Okada: On the action of electric current on fishes II. Jour. Imper. Fisher. Inst. XXV, 1 (1929).
(6) F. Scheminzky: Der Fischfang mit Elektrischem Strom. Nachrichtenblatt f. Fischzucht u. Fischerei. 1 (1927); Versuche über Elektrotaxis und Elektronarkose. Pflüger's Arch. f. d. ges. Physiologie. Bd. 202 (1924).
(7) M. Okada: On the action of electric current on fishes I. Jour. Imper. Fisher. Inst. XXIV, 2 (1929).

required for giving rise to the steps of responses has the least value when the direction of stream line of the current is parallel to the body length of a fish.

The screens above referred to are effective in stopping a fish-group but they are of little effect on leading the movement of a fish-group as shown by Okada's experiment.[8] Fishes going up a stream along a side on which a branch opens may be led into the branch easily by screening the upper stream. Hence any means leading fishes from a side to the opposite one can be used effectively to lead them into the branch.

Formerly the author[9] put several thin wire electrodes at intervals, parallel to a side of a water course, covering the bottom from the side to $\frac{1}{3}$ midway of the breadth of the stream and he found that, when fishes went up the stream and entered the electrified region a part of them escaped from that region to the opposite side, while the other part turned back and went down the stream. In the present paper the author wishes to give an account of the course of the experiment done by him on the screen of this form.

Model streams used in this experiment are (A) a wooden conduit, 88 cm. broad and 360 cm. long and (B) a concrete one, 90 cm. broad and 885 cm. long. Electrodes were thin wires, 260 cm. long in (A), and 675 cm. long in (B). Electrodes in two rows started from the upstream end of the conduit and parallel to a side, one row on the bottom and the other on a plane 10 cm. high above the bottom. Extreme electrodes in each row kept a space of 29 or 30 cm. in (A) and 32 cm. in (B). An alternating electric current of 50 cycles single phase was supplied and the terminal voltage was varied by means of a variable transformer. Fishes used in this experiment were variegated carp 6～7 cm., rainbow trout 13～17 cm. and gold-fish 6～8 cm. A number of fishes of each kind were divided in several classes which have some tens of members. Fishes in a class were used for about an hour and a half, once a day.

When the fishes in a conduit started from a space (P, Fig. 1) near the downstream end and approached the electrified region, a small part of them turned back and went down the stream in front of that region, while fishes of other part entered that region. But a larger part of the fishes which entered the electrified region either turned back and went

(8) M. Okada: Note on leading the movement of fish-groups by electric current. Jour. Imper. Fisher. Inst. XXIV, 5 (1929).

(9) M. Tauti: Some experiments on fish-way. *Denkikyôkwai-Kwaihô*. 87, (1929).

down the stream or escaped from that region to the mid-stream in the sections of that region (I, II,..VI, fig. 1, of equal depth and arranged in order), whereas the rest broke through the whole region.

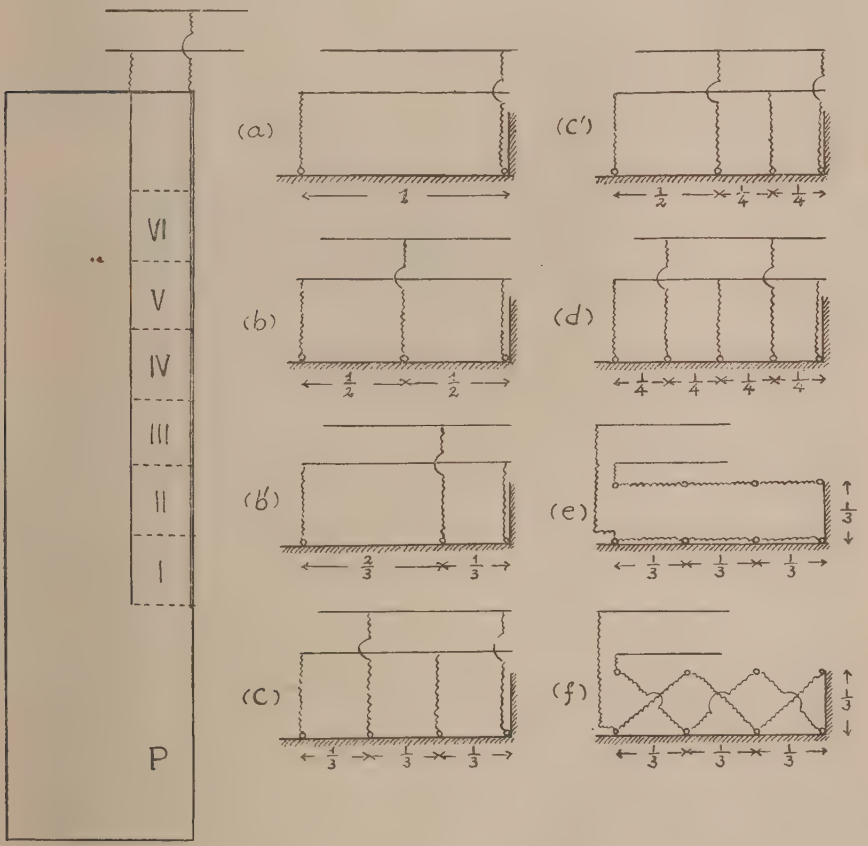

Fig. 1.

Arrangement of electrodes.

The records of observation are given in Tab. I. Tab. II gives the percentage of fish-groups which broke through the electrified region of various depths and the ratio of fish-groups which turned back and went down stream in the whole sections to those which escaped from the electrified region to the mid-stream. To show how the stopping effect of screans of this form varies with the density of current supplied, the ratio of the percentages of both cases where the current was supplied and not is calculated from Tab. II. The result of calculation is given in Tab. III.

Okada[5] found that the general relation between the probability for a fish-group to be prevented in its course upstream by a part of electrified region between two parallel net-formed electrodes, r, and the voltage gradient, v, can be expressed by the following equation:

$$r=\frac{1}{\sqrt{2\pi}\,\sigma}\int_0^{A\log\frac{v}{v_0}} e^{-\frac{1}{2}\left(\frac{x-x_0}{\sigma}\right)^2}dx,$$

where A, v_0, x_0 and σ are constants. Fig. 2 shows that, in the present case, Okada's formula holds good for the probability for a fish-group to be prevented in its course upstream and the voltage gradient. In this figure, the relation between the value of $\varphi(p)$ which equalizes $\frac{1}{\sqrt{2\pi}}\int_{-\infty}^{\varphi(p)} e^{-\frac{1}{2}x^2}dx$ and the ratio of percentages of fish-groups breaking through the electrified region of both cases where the current was supplied and not, p, and the logarithm of corresponding value of the terminal voltage, $\log V$, is plotted in several cases from Tab. III.

From Tab. III, the terminal voltage is obtained when the percentage of fish-groups breaking through the electrified region of several depths is equal to the half of that in the case where the current is not supplied. The obtained values are given in Tab. IV. Fig. 3 shows that the relation between the obtained value of terminal voltage, V, and the corresponding value of the depth of electrified region, L, obeys the next formula

$$\log V=a-bL,$$

where a and b are some constants.

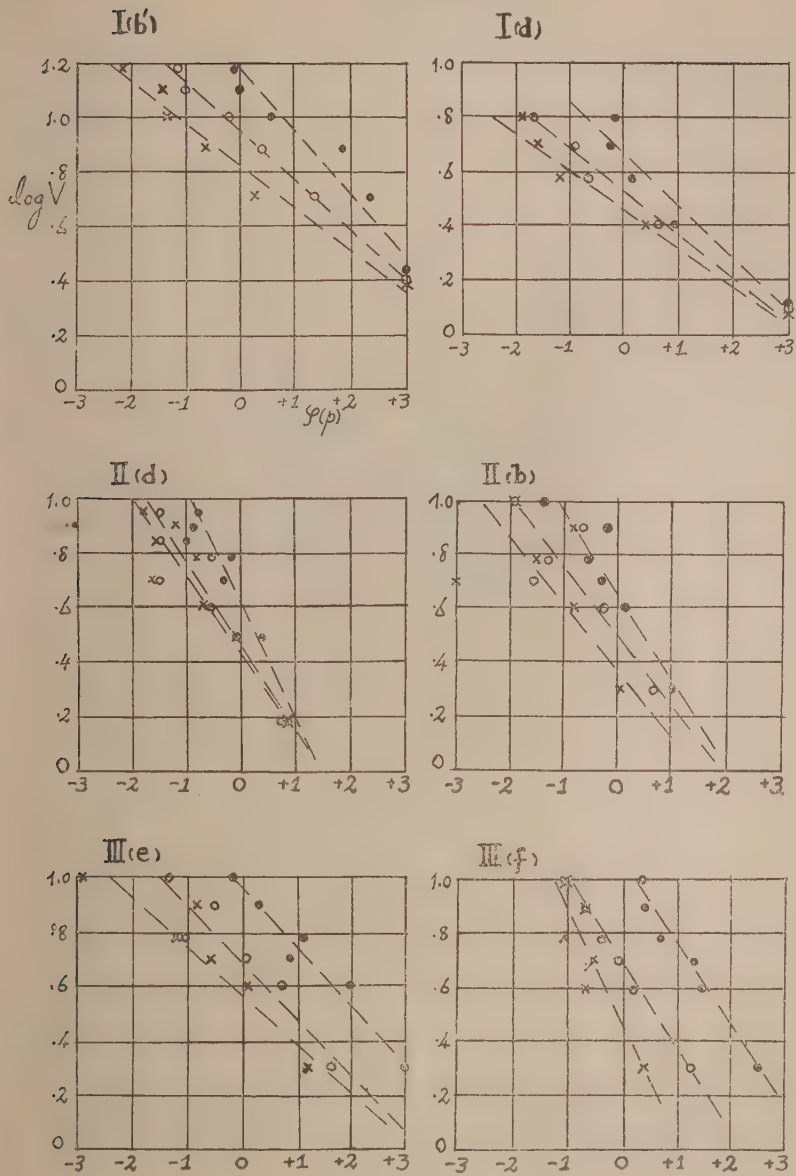

Fig. 2

Relation between the value of $\varphi(p)$ which equalizes $\frac{1}{\sqrt{2\pi}}\int_{-\infty}^{\varphi(p)} e^{-\frac{1}{2}x^2}\,dx$ and the ratio of percentages of fish-groups breaking through the electrified region of both cases where the current was supplied and not, p, and the logarithm of corresponding value of terminal voltage, log V.

I Carp. Depth of electrified region: ●....33, ○....99, ×....165 cm.
Arrangement of electrodes: (b'), (d).

II Rainbow trout. Depth of electrified region: ●....225, ○....450, ×....675 cm.
Arrangement of electrodes: (d), (b).

III Gold-fish, Depth of electrified region: ●....33, ○....99, ×....165 cm.
Arrangement of electrodes: (e), (f).

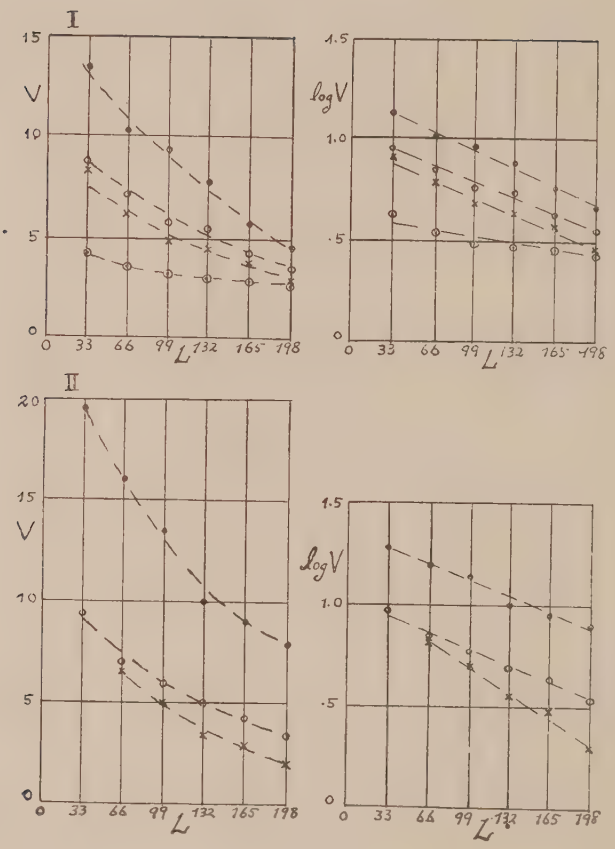

Fig. 3

Relation between the depth of the electrified region, L, and the terminal voltage, V, when the percentage of fish-groups breaking through that region is equal to the half of that in the case where the current is not supplied.

I Carp. Arrangement of electrodes: ●....(b'), ○....(b) ×....(c'), ⊙....(d)
II Gold-fish. 〃 : ●....(c), ○....(e) ⊙....(f)

Table I

Number of fish-groups which turned back and went downstream in front of the electrified region and in each section of that region (I, II, .., Fig. 1), number of fish-groups which escaped from the electrified region to the mid-stream in each section and that of those which broke through the whole sections.

Carp 6~7 cm., model (A), water-temp. 11-16°C, interval of extreme electrodes 29 cm., depth of each section 33 cm., still water.

Arrangement of electrodes	Terminal voltage	front	I		II		III		IV		V		VI		Break through	Total
		t.b.	t.b.	es.	t.b.	es.	t.b.	es.	t.b.	es.	t.b.	es.	t.b.	es.		
(b')	0	0	2	6	4	4	3	4	6	2	4	5	2	10	42	94
	2.5	0	3	2	6	3	5	5	3	3	5	9	2	12	53	111
	5.0	0	3	5	2	10	3	4	3	10	4	13	2	13	14	86
	7.5	0	2	5	4	9	1	10	4	6	2	10	1	4	5	63
	10.0	0	7	17	6	12	2	5	4	6	2	7	0	1	3	72
	12.5	0	8	26	3	13	0	7	1	3	0	1	0	3	0	65
	15.0	7	14	20	3	13	3	4	1	3	0	2	0	1	0	71
(b)	0	0	6	3	4	1	2	3	4	5	5	4	8	8	36	89
	2.5	0	4	6	4	4	3	3	3	6	7	9	7	8	24	88
	5.0	1	7	11	4	8	3	5	5	4	5	8	3	6	8	78
	7.5	4	3	32	4	6	2	2	0	4	0	3	1	3	1	65
	10.0	0	13	17	7	5	4	5	2	2	1	2	1	2	1	62
(c')	0	0	2	4	2	2	2	4	1	6	2	6	4	11	37	83
	2.5	0	3	3	3	6	2	4	6	10	5	4	8	10	21	85
	5.0	0	9	17	7	8	3	7	4	4	2	8	1	7	6	83
	7.5	0	10	24	5	11	5	8	1	7	1	2	0	2	1	77
	10.0	8	9	24	1	4	1	3	0	1	0	1	0	0	0	52
(d)	1.25	0	3	4	5	2	3	2	5	6	5	7	5	15	28	90
	2.50	0	5	16	2	10	3	4	2	5	2	8	3	10	15	85
	3.75	5	15	22	8	8	7	7	1	5	3	2	1	1	3	88
	5.00	6	15	42	4	11	2	7	1	3	1	6	0	1	2	101
	6.25	3	16	38	5	20	3	8	1	1	0	0	0	1	1	97
	0	0	6	8	8	11	7	15	11	11	12	12	18	15	70	204

Rainbow trout 13~17 cm., model (B), water-temp. 10.~12.5°C, interval of extreme electrodes 32 cm., depth of each secrion 225 cm., speed of stream 25 cm/sec.

Arrangement of electrodes	Terminal voltage	front	I		II		III		Break through	Total
		t.b.	t.b.	es.	t.b.	es.	t.b.	es.		
(d)	0	0	2	1	0	2	0	2	22	29
	1.5	1	10	4	0	4	0	1	32	52
	3.0	3	11	30	6	15	1	3	38	107
	4.0	2	3	26	1	12	1	1	10	56
	5.0	5	8	30	2	14	0	1	2	62
	6.0	2	7	37	4	8	2	4	12	76
	7.0	1	3	39	0	4	0	1	2	50
	8.0	3	7	34	3	7	0	1	5	60
	9.0	6	6	39	2	6	0	2	2	63
	10.0	7	28	45	16	10	4	1	16	127
(b)	2.0	1	8	10	3	9	1	15	32	79
	4.0	4	19	16	13	3	8	2	13	78
	5.0	2	0	33	7	9	0	2	0	53
	6.0	3	8	30	1	10	0	1	3	56
	8.0	7	10	29	5	8	1	2	12	74
	10.0	6	17	34	2	1	0	0	1	61
(a)	4.0	1	6	6	4	1	0	5	23	46
	6.0	0	9	6	8	9	2	4	22	60
	8.0	3	12	19	7	6	2	5	16	70
	10.0	1	6	14	7	8	1	3	15	55

Gold-fish 6~8 cm., model (A), water-temp. 6.8~10.0°C, interval of extreme electrodes 30 cm., depth of each section 33 cm., still water.

Fishes were forced to enter the electrified region.

Number of fish-groups which turned back to go downstream and that of those which escaped to mid-stream were not recorded separately.

Arrangement of electrodes	Terminal voltage	I	II	III	IV	V	VI	Break through	Total
(e)	0	0	0	0	0	5	6	43	54
	2.0	0	1	1	2	3	6	17	30
	5.0	1	3	7	4	4	7	23	49
	7.5	11	7	6	9	6	6	20	65
	9.5	0	2	9	9	6	3	30	59
	11.5	1	8	9	8	8	4	21	59
	13.5	16	11	8	5	3	3	10	56
	15.5	3	6	6	3	1	0	8	27
	20.0	27	14	0	1	1	0	1	44
(e)	0	0	0	1	0	3	6	44	54
	2.0	0	3	0	3	2	4	24	36
	4.0	2	7	6	7	8	10	18	58
	5.0	13	7	11	9	7	4	12	63
	6.0	6	17	10	1	1	2	2	39
	8.0	28	15	9	2	5	4	10	73
	10.0	18	8	3	3	0	0	0	32
(f)	0	0	0	0	2	3	12	77	94
	2.0	1	2	6	12	5	10	32	68
	4.0	4	8	12	12	7	5	9	57
	5.0	17	13	8	8	4	8	12	70
	6.0	16	17	10	10	3	2	6	64
	8.0	21	15	9	1	1	2	12	61
	10.0	21	15	6	4	4	3	5	58

TABLE II

Percentage of the number of fish-groups which broke through the electrified region of several depths to the total number, and ratio of the number of fish-groups which turned back to go downstream in the whole sections to that of those which escaped from the electrified region to the mid-stream.

Carp.

Arrangement of electrodes	Terminal voltage	Percentage of breaking through the following depth							Ratio of turning back to escaping
		0cm	33cm	66cm	99cm	132cm	165cm	198cm	
(b')	0	100	92	81	76	67	58	45	.67
	2.5	100	95	83	78	73	60	48	.80
	5.0	100	91	77	69	53	34	16	.31
	7.5	100	89	68	51	35	16	8	.32
	10.0	100	67	42	32	18	6	4	.44
	12.5	100	48	23	12	6	5	0	.23
	15.0	90	42	20	10	4	1	0	.65
(b)	0	100	90	85	79	69	58	41	1.20
	2.5	100	89	80	73	63	44	27	.78
	5.0	99	76	60	50	39	22	10	.67
	7.5	94	40	25	19	12	8	2	.28
	10.0	100	52	32	18	11	6	2	.85
(c')	0	100	93	88	81	72	63	45	.40
	2.5	100	93	83	75	57	46	25	.73
	5.0	100	69	51	39	29	17	7	.51
	7.5	100	56	35	18	8	4	1	.41
	10.0	85	21	12	4	2	0	0	.57
(d)	0	100	93	84	73	63	51	34	.86
	1.25	100	93	84	79	67	53	31	.72
	2.50	100	75	61	53	45	33	18	.32
	3.75	95	52	34	18	11	6	3	.89
	5.00	94	38	23	14	10	3	2	.41
	6.25	97	41	16	4	2	2	1	.41

Rainbow trout.

Arrangement of electrodes	Terminal voltage	Percentage of breaking through the following depth				Ratio of turning back to escaping
		0cm	225cm	450cm	675cm	
(d)	0	100	90	83	76	.40
	1.5	98	71	63	61	1.22
	3.0	97	59	39	36	.44
	4.0	97	45	22	18	.18
	5.0	92	31	5	3	.33
	6.0	97	40	24	16	.31
	7.0	98	14	6	4	.09
	8.0	95	17	10	8	.31
	9.0	91	19	6	3	.30
	10.0	95	37	17	13	.98
(b)	2.0	99	76	61	40	.38
	4.0	95	50	30	17	2.10
	5.0	96	34	4	0	.20
	6.0	95	27	7	5	.29
	8.0	91	38	20	16	.59
	10.0	91	7	2	2	.71
(a)	4.0	98	72	61	50	.92
	6.0	100	75	47	37	1.00
	8.0	96	52	33	23	.80
	10.0	98	62	35	27	.56

Gold-fish.

Arrangement of electrodes	Terminal voltage	Percentage of breaking through the following depth						
		0cm	33cm	66cm	99cm	132cm	165cm	198cm
(c)	0	100	100	100	100	100	91	80
	2.0	100	100	97	93	87	77	57
	5.0	100	98	92	77	69	61	47
	7.5	100	83	72	63	49	40	31
	9.5	100	100	96	81	66	56	51
	11.5	100	98	85	70	56	43	36
	13.5	100	72	52	38	29	23	18
	15.5	100	89	67	45	33	30	30
	20.0	100	39	7	7	5	2	2
(e)	0	100	100	100	98	98	92	81
	2.0	100	100	92	92	83	78	67
	4.0	100	97	85	74	62	48	31
	5.0	100	80	68	51	37	26	19
	6.0	100	85	41	15	13	10	5
	8.0	100	62	41	29	26	19	14
	10.0	100	44	19	9	0	0	0
(f)	0	100	100	100	100	98	95	82
	2.0	100	99	96	87	69	62	47
	4.0	100	93	79	58	37	25	16
	5.0	100	90	57	46	34	29	17
	6.0	100	75	48	33	17	13	9
	8.0	100	66	41	26	25	23	20
	10.0	100	64	38	28	21	14	9

TABLE III

Ratio of percentage of fish-groups which broke through the electrified region of several depths of both cases where the current was supplied and not.

Carp.

Arrangement of electrodes	Terminal voltage	Depth of the electrified region in cm.					
		33	66	99	132	165	198
(b')	0	100	100	100	100	100	100
	2.5	103	103	103	109	103	107
	5.0	99	95	91	78	59	35
	7.5	97	84	67	52	28	18
	10.0	73	52	42	17	10	9
	12.5	52	28	16	9	9	0
	15.0	46	25	13	6	2	0
(b)	0	100	100	100	100	100	100
	2.5	99	94	92	91	76	66
	5.0	85	71	64	57	38	24
	7.5	45	30	24	17	14	5
	10.0	58	38	23	16	10	5
(c')	0	100	100	100	100	100	100
	2.5	100	95	93	79	73	56
	5.0	74	58	48	40	27	16
	7.5	60	40	22	11	6	2
	10.0	23	14	5	3	0	0
(d)	0	100	100	100	100	100	100
	1.25	100	100	108	106	105	92
	2.50	81	73	73	71	65	53
	3.75	56	40	25	17	12	9
	5.00	41	27	19	16	6	6
	6.25	44	19	5	3	4	3

Rrainbow trout.

Arrangement of electrodes	Terminal voltage	Depth of the electrified region in cm.		
		225	450	675
(d)	0	100	100	100
	1.5	79	76	80
	3.0	66	47	47
	4.0	50	27	24
	5.0	35	6	4
	6.0	45	29	21
	7.0	16	7	5
	8.0	19	12	11
	9.0	21	7	4
	10.0	41	20	17
(b)	2.0	85	76	53
	4.0	56	38	22
	5.0	38	5	0
	6.0	30	9	7
	8.0	42	25	21
	10.0	8	3	3
(a)	4.0	80	76	62
	6.0	83	59	46
	8.0	58	41	29
	10.0	69	44	34

Gold-fish.

Arrangement of electrodes	Terminal voltage	Depth of the electrified region in cm.					
		33	66	99	132	165	198
(c)	0	100	100	100	100	100	100
	2.0	100	97	93	87	85	71
	5.0	98	92	77	69	67	59
	7.5	83	72	63	49	44	39
	9.5	100	96	81	66	62	64
	11.5	98	85	70	56	47	45
	13.5	72	52	38	29	25	22
	15.5	89	67	45	33	33	37
	20.0	39	7	7	5	2	2
(e)	0	100	100	100	100	100	100
	2.0	100	92	94	85	85	83
	4.0	97	85	76	64	52	38
	5.0	80	68	52	38	28	23
	6.0	85	41	15	13	11	6
	8.0	62	41	30	27	21	17
	10.0	44	19	9	0	0	0
(f)	0	100	100	100	100	100	100
	2.0	99	96	87	71	65	57
	4.0	93	79	58	38	26	20
	5.0	90	57	46	35	30	21
	6.0	75	48	32	17	14	11
	8.0	66	41	26	26	24	25
	10.0	64	38	28	21	15	11

Table IV

Terminal voltage when the percentage of fish-groups breaking through the electrified region of several depths is equal to the half of that in the case where the current is not supplied.

Carp.

Arrangement of electrodes	L cm					
	33	66	99	132	165	198
(b')	13.3	10.2	9.2	7.7	5.7	4.5
(b)	8.7	7.1	5.8	5.4	4.2	3.5
(c')	8.2	6.1	4.9	4.4	3.8	2.9
(d)	4.2	3.4	3.1	3.0	2.9	2.6

Rainbow trout.

Arrangement of electrodes	L cm		
	225	450	675
(d)	4.0	3.0	2.5
(b)	4.5	3.7	2.4
(a)	—	6.5	4.8

Gold-fish.

Arrangement of electrodes	L cm					
	33	66	99	132	165	198
(c)	19.6	16.0	13.5	10.0	9.0	8.0
(e)	9.3	7.0	6.0	5.0	4.2	3.3
(f)	—	6.5	5.0	3.5	3.0	2.0

The equipotential lines were determined at regular interval, $\frac{1}{10}$ of the terminal voltage, in a vertical plane perpendicular to a side of conduit. From charts in which the series of equipotential lines were drawn we measured the maximum and minimum values of voltage gradient with the terminal voltage in the layer in which the three kinds of fish swam upstream. Tab. V gives the maximum and minimum values of voltage gradient in that layer calculated from Tab. IV, when the percentage of fish-groups breaking through the electrified region of several depths is equal to the half of that in the case where the current is not supplied.

Table V

Voltage gradient, max. and min., measured with terminal voltage in the layer in which fishes swim upstream. Max. and min. values of voltage gradient, in volt per cm., in that layer when the percentage of fish-groups breaking through the electrified region of several depths is equal to the half of that in the case where the current is not supplied.

Carp, 2 cm. high above the bottom.

Arrangement of electrodes	Voltage gradient with terminal voltage	Depth of the electrified region, L, in cm.					
		33	66	99	132	165	198
(b′)	— ～.043	— ～.58	— ～.44	— ～.39	— ～.31	— ～.25	— ～.20
(b)	.003～.057	.026～.50	.021～.40	.017～.33	.016～.31	.013～.24	.010～.20
(c′)	.006～.048	.049～.39	.037～.29	.029～.24	.026～.21	.023～.18	.017～.14
(d)	.012～.057	.050～.24	.041～.19	.037～.18	.036～.17	.035～.17	.031～.15

Rainbow trout, 3 cm. high above the bottom.

Arrangement of electrodes	Voltage gradient with terminal voltage	Depth of the electrified region, L, in cm.		
		225	450	675
(d)	.010～.045	.040～.18	.030～.14	.025～.11
(b)	.002～.050	.009～.22	.007～.18	.005～.12
(a)	— ～.035	—	— ～.23	— ～.17

Gold-fish, 5 cm. high above the bottom.

Arrangement of electrodes	Voltage gradient with terminal voltage	Depth of the electrified region, L, in cm.					
		33	66	99	132	165	198
(c)	.008～.016	.15～.31	.13～.26	.11～.22	.08～.16	07～.14	.06～.13
(e)	. 05	.46	.35	.30	.25	.21	.17
(f)	.02 ～ .05	—	.13～.33	.10～.25	.07～.18	.06～.15	.04～.10

On gold-fish used in the present study, the minimum value of voltage gradient at which it suddenly felt the current taking a rapid motion and at which it fell in syncoptic condition was measured in uniformly electrified region of alternating current of 50 cycles single phase when the direction of voltage gradient coincided with the front-and-rear-, right-and-left- and up-and-down- direction with respect to the fish-body. Tab. VI gives the result of mearement. In a uniformly electrified region, of carp, rainbow trout and gold-fish, Okaka[7,8] mea-

sured the average sensitivity to an alternating current of 50 cycles single phase when the line of flow was parallel to the fish-body and he obtained the result as shown in Tab. VII. As the remarkable difference can not be found between the sensitivity of fishes of the three kinds as shown in Tab. VII, we may say from Tabs. V and VI that, to reduce the percentage of fish-groups by one half by electrifying the region several times longer than the body length of fishes, the maximum value of voltage gradient in that region must be several times larger than the minimum value of voltage gradient at which the fishes suddenly felt the current taking a rapid motion. From the result on gold-fish given in Tab. V, we can infer that a uniform electrification has the effect of stopping fishes less than a non-uniform one.

TABLE VI

Gold-fish 5.0~6.3 cm., water-temp. 9.0~13.0°C, specific conductivity of water $6\sim9\times10^{-5}$ cm/ohm.

Direction of voltage gradient with respect to fish-body	Minimum value of voltage gradient, in volt/cm., at which	
	fish felt the current taking a rapid motion	fish fell in syncoptic condition
front and rear	.036	.43
right and left	.18	.95
up and down	.13	1.05

TABLE VII

Kind of fishes	Temperature of water °C	Specific conductivity of water cm./ohm.	Minimum value of voltage gradient, in volt/cm., at which	
			fish felt the current taking a rapid motion	fish fell in syncoptic condition
Carp. 4~7cm.	22.5	7.5×10^{-4}	.027	—
Rainbow trout 7.5~17.0cm.	13~18	5.6×10^{-5}	.026	.59
Gold-fish 4.6~10.2cm.	12~15	$6\sim9\times10^{-5}$	.030	—

Tab. VIII calculated from Tabs. II and V, gives the relation between the ratio of fish-groups which turned back and went downstream in the whole sections of the electrified region to those which escaped from that

region to the mid-stream and the maximum value of voltage gradient in the layer in which fishes went upstream. Fig. 4 shows graphically the relation given in Tab. VIII. From this figure we find that the number of fish-groups escaping from the electrified region to the mid-stream is comparatively large when the maximum value of voltage gradient in that layer is several times larger than the minimum value of voltage gradient at which the fishes suddenly felt the current taking a rapid motion.

Table VIII

Relation between the ratio of fish-groups which turned back and went downstream in the whole sections of the electrified region to those which escaped from that region to the mid-stream and the maximum value of voltage gradient in the layer in which fishes went upstream.

Carp, 2 cm. high above the bottom.

Arrangement of electrodes	Max. voltage gradient measured with terminal voltage	Terminal voltage volt	Max. voltage gradient volt/cm.	Ratio
(b′)	.043	0	0	.67
		2.5	.11	.80
		5.0	.21	.31
		7.5	.32	.32
		10.0	.43	.44
		12.5	.54	.23
		15.0	.64	.65
(b)	.057	0	0	1.20
		2.5	.14	.78
		5.0	.28	.68
		7.5	.43	.28
		10.0	.57	.85
(c′)	.048	0	0	40
		2.5	.12	.73
		5.0	.24	.51
		7.5	.36	.41
		10.0	.48	.57
(d)	.057	0	0	.86
		1.25	.06	.72
		2.50	.14	.32
		3.75	.21	.89
		5.00	.28	.41
		6.25	.36	.41

Rainbow trout, 3 cm. high above the bottom.

Arrangement of electrodes	Max. voltage gradient measured with terminal voltage	Terminal voltage volt	Max. voltage gradient volt/cm.	Ratio
(d)	.045	0	0	.40
		1.5	.07	1.22
		3.0	.13	.44
		4.0	.18	.18
		5.0	.23	.33
		6.0	.27	.31
		7.0	.31	.09
		8.0	.36	.31
		9.0	.40	.30
		10.0	.45	.98
(b)	.050	2.0	.10	.38
		4.0	.20	2.10
		5.0	.25	.20
		6.0	.30	.29
		8.0	.40	.59
		10.0	.50	.71
(a)	.035	4.0	.14	.92
		6.0	.21	1.00
		8.0	.28	.80
		10.0	.35	.56

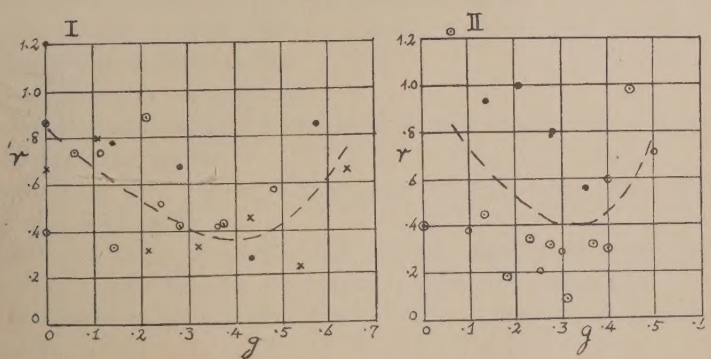

Fig. 4.

Relation between the ratio, r, of fish-groups which turned back to go downstream in the whole sections of the electrified region to those which escaped from that region to the mid-stream and the maximum value of voltage gradient, g, in the layer in which fishes went upstream.

I Carp. Arrangement of electrodes: ×....(b'), •....(b), ○....(c'), ⊙....(d)

II Rainbow trout. „ : • .. (a), ○....(b), ⊙....(d)

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